Optimization of the Superfinishing Process Using Different Types of Stones

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Abstract- Super finishing is a micro-finishing process that produces a controlled surface condition on circular parts. It is not primarily a sizing operation and its major purpose is to produce a surface on a work piece capable of sustaining uneven distribution of a load by improving the geometrical accuracy. The wear life of the parts micro finished to maximum smoothness is extended considerably. Super finishing is a slow speed, low temperature, high precision abrasive machining operation for removing minute amounts of surface material In this paper critical parameters which affects surface roughness are determined. According to the design of experimentation, mathematical model for four different types of abrasive stones used is proposed. In order to get minimum values of the surface roughness, optimization of the mathematical model is done and optimal values of the examined factors are determined. The obtained results are, according to the experiment plan, valid for the testing of material MS12.

Index Terms **—Amplitude of vibration, contact pressure, surface speed, surface roughness, optimisation**

I. INTRODUCTION

The super finishing process is not basically stock removal process and material removal rate reported in the literature is of least significance and the performance of the process is generally evaluated by comparing it with that of grinding. The earlier research work considered the need of a super finishing process for improving the surface finish. However, the optimal parameters were not illustrated in this work (awari, 1995) several authors have investigated the process of super finishing. (Liu, et al.,1999). Though some of these studies have considered possible optimization of parameters, only a few of them can be applied in practice. This paper is concerned with the selection of optimum super finishing conditions. Experimental results are presented that shows the effect of contact pressure, surface sped, amplitude of vibration, and grit size on super finishing performance. These results are used as a basis for selecting super finishing conditions.

II.TESTING CONDITIONS

Testing were executed on a "SUPFINA" (Germany) super finishing test rig, a pneumatically operated mounted on a standard centre lathe OKUMA (Japanese). Experiments were conducted on the cylindrical turned work-pieces of mild steel (Rocker l hardness H 30). Most experiments were conducted with the aluminum oxide stone in a vitrified bond with wax treatment. The stones were supplied with a rectangular cross section, 28 mm in width (axial direction) and 18 mm in thickness (circumferential direction) and having stone face area of 1080 mm2. The stones used contained grit size abrasives with mesh number 320 (Stone A), 500 (Stone B), 800 (Stone C) and 1000 (Stone D). The various stones used are presented in the table 1.

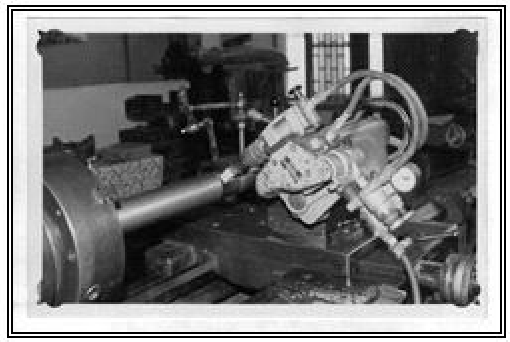

Figure 1: Experimental Set-up

TABLE1
LIST OF VARIOUS SUPERFINISHING STONES USED FOR EXPERIMENTATION

Stone	Alumina Abrasive type	Type make	Hardness
1	Fused white	A (320)	59.7
2	Fused white	B (500)	60.3
3	Fused white	C (600)	58.3
4	Fused white	D (1000)	60.3

The parameters varied are contact pressure, amplitude of vibration of stone, surface speed of work-piece. The work piece rotational speed and amplitude of vibration are separately controlled. The super finishing cycle was controlled. The average roughness Ra and Rt was measured by the Homework D-7730 V.S. Schewenningen and Perthometer.

A. Formulation of Experimental Data Based Model

Five independent pi terms ($\pi 1$, $\pi 2$, $\pi 3$, $\pi 4$, $\pi 5$) and one dependent pi terms ($\pi D1$,) have been used in the design of experimentation and are available for the model formulation.

Following four mathematical relationships are formed for four different types of abrasive stones used in the experimentation.

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$\pi D1 = k1x(\pi 1)a1x(\pi 2)b1x(\pi 3)c1x(\pi 4)d1x(\pi 5)e1$

$\pi D2 = k2x(\pi 1)a2x(\pi 2)b2x(\pi 3)c2x(\pi 4)d2x(\pi 5)e2$

$\pi D3 = k3x(\pi 1)a3x(\pi 2)b3x(\pi 3)c3x(\pi 4)d3x(\pi 5)e3$

$\pi D4 = k4x(\pi 1)a4x(\pi 2)b4x(\pi 3)c4x(\pi 4)d4x(\pi 5)e4$

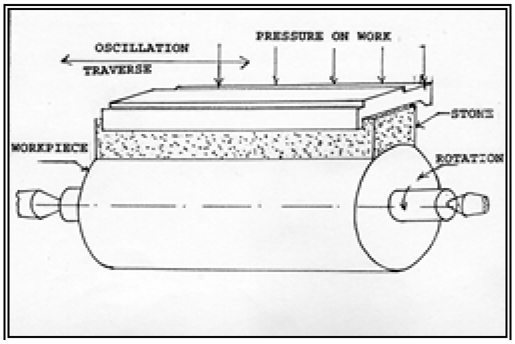

Figure 2: Superfinishing stone in contact with the workpiece

III. RESULTS OF EXPERIMENTS AND OPTIMIZATION

As it was mentioned before, surface roughness during Superfinishing is influenced by lots of impact factors. Due to limited number of factors that could be examined in the same time, in this paper are chosen:

- Contact pressure,
- Amplitude of vibration,
- Surface speed,
- Machining time,

According to the experimental results, measured surface roughness and Statistical analysis of data, using software Design Experiment, was done.Four mathematical models have been developed for the phenomenon.

The various mathematical models for different stones are stated below.

Ra = μg-0.0213 A-0.3478 vp0.0417 t0.1374 p-1.1504

- (1) For Stone A

Ra = μg-0.0143 A-0.1457 vp0.0533 t-0.9596 p-3.0166

- (2) For Stone B

Ra = μg0.6465 A-0.7608 vp0.4108 t0.6205 p0.1264

- (3) For Stone C

Ra = μg0.1848 A-0.6120 vp-0.1692t -0.1377p1.1297

- (4) For Stone D

The ultimate objective of this work is not merely developing the models but to find out best set of independent variables, which will result in maximization/minimization of the objective functions. The models have non linear form; hence it is to be converted into a linear form for optimization purpose. This can be achieved by taking the log of both the sides of the model. The linear programming technique is applied which is detailed as below.

$\pi 01 = K1 \times (\pi 1)\ a1 \times (\pi 2)\ b1 \times (\pi 3)\ c1 \times (\pi 4)\ d1 \times (\pi 5)\ e1$

Taking log of both the sides of the Equation,

$\text{Log}\ \pi 01 = \text{Log}\ K1 + a1 \times \text{Log}(\pi 1) + b1 \times \text{Log}(\pi 2) + c1 \times \text{Log}(\pi 3) + d1 \times \text{Log}(\pi 4) + e1 \times \text{Log}(\pi 5)$

Let,

Log $\pi 0$ = Z,

Log K1 = k1,

Log ($\pi 1$) = X1,

Log ($\pi 2$) = X2,

Log ($\pi 3$) = X3,

Log ($\pi 4$) = X4,

Log ($\pi 5$) = X5

Then the linear model in the form of first degree polynomial can be written as under

$Z = K + a \times X1 + b \times X2 + c \times X3 + d \times X4 + e \times X5$

This, Equation constitutes for the optimization or to be very specific for maximization for the purpose of formulation of the problem. The constraints can be the boundaries defined for the various independent pi terms involved in the function. During the experimentation the ranges for each independent pi terms have been defined, so that there will be two constraints for each independent variable as under. If one denotes maximum and minimum values of a dependent pi term $\pi 1$ by $\pi 01$max and $\pi 01$min respectively then the first two constraints for the problem will be obtained by taking log of these quantities and by substituting the values of multipliers of all other variables except the one under consideration equal to zero. Let the log of the limits be defined, as C1 and C2 {i.e. C1=log ($\pi 01$max) and C2=log ($\pi 01$min)}.

Thus, the Equations of the constraints will be as under.

1 x X1+ 0 x X2 + 0 x X3 + 0 x X4 + 0 x X5 d” C1

1 x X1+ 0 x X2 + 0 x X3 + 0 x X4 + 0 x X5 e” C2

The other constraints can be likewise found as under,

0 x X1+ 1 x X2 + 0 x X3 + 0 x X4 + 0 x X5 d” C3

0 x X1+ 1 x X2 + 0 x X3 + 0 x X4 + 0 x X5 e” C4

0 x X1+ 1 x X2 + 0 x X3 + 0 x X4 + 0 x X5 d” C5

0 x X1+ 1 x X2 + 0 x X3 + 0 x X4 + 0 x X5 e” C6

0 x X1+ 1 x X2 + 0 x X3 + 0 x X4 + 0 x X5 d” C7

0 x X1+ 1 x X2 + 0 x X3 + 0 x X4 + 0 x X5 e” C8

After solving this linear programming problem one gets the minimum value of Z. The values of the independent pi terms can then be obtained by finding the antilog of the values of Z, X1, X2, X3, X4 and X5. The actual values of the multipliers and the variables are found.

The optimum values are obtained by using MS Solver available in MS Excel.

TABLE 2. OPTIMUM VALUES OF PARAMETERS

Stone	Ra	P	Vp	T	A
A	79 x 10-8 m	151022 N/m2	268 rpm	178.2 sec.	2.95 x 10-3 m
B	38 x 10-8 m	101989 N/m2	260 rpm	172.2 sec.	2.05 x 10-3 m
C	85 x 10-8 m	141215 N/m2	1396 rpm	138 sec.	1.96 x 10-3 m
D	97 x 10-8 m	150041 N/m2	1396 rpm	184.2 sec.	2.96 x 10-3 m

IV. CONCLUSION

In this paper effect of contact pressure, amplitude of vibration, surface speed of work-piece, operation tine, grit size of abrasive particles, on surface roughness during superfinishing process has been examined. It is observed that surface roughness decreases with increase in contact pressure; however there is limit on the maximum contact pressure that can be employed. Very high contact pressure may result in scoring the surface finished produced.

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Optimal value of influencing parameters is also determined. Optimal machining parameters in superfinishing are usually selected to achieve a high volume of material removal, thereby remove the macro-geometrical and damaged layers with minimum process time which is directly inclined towards economy of the process. Furthermore it is expected that such performance obtained under these optimal machining conditions make it possible to replace any fine conventional machining process like hard turning by superfinishing. The strongest effect on roughness has contact pressure and then follows machining time, workpiece speed and amplitude of vibration. Applying the partial derivation as an optimization method on the function (1), optimal value of influencing parameter is also determined. The obtained results are, according to the experiment plan, valid for the testing of material MS12. The test results are to be probably applied to other materials, however, has to be proved for each separate case.

V. REFERENCES

[1]. Ardhapurkar P.M., Thesis on 'Study and Performance Evaluation of Honing Process', *SSGMCE, Amravati University, Amravati.* (1997)

[2]. Buzatu, C., Popescu, I "Tolerances and fits for finemechanical products."*Transilvania" University Publishing House, Brasov*,1985 (in Romanian)

[3]. Cebalo. R., Baggic D. 'Fundamental of superfinishing process ', *5th international Scientific conference on production engineering. Opatija* 1999

[4]. Cebalo R. , Bilic B., Baggic D., ' optimization of superfinishing process ', *3rd DAAAM International Conference on Advance Technologies for developing countries, Split Cooatia* 23 rd June 2004.

[5]. Chang H.S. S. Chandrasekar (2008)Experimental analysis on evolution of superfinished surface texture" *journal of Material Processing Technology* (365-371)

[6]. Guo Y.B and Zhang Y and Zhong J.A. and Syogi K "Optimization of honing wheel structure parameters in ultra-precision plane honing" *Tohoku university, Sendai, Japan,*. (2002)

[7]. Chang S.H., T. N. Farris, "Experimental analysis on evolution of superfinihsed surface texture", *journal of material processing technology,* 2003, 365-371.

[8]. P.C. Pandey and C.K.Singh, "Production Engineering Sciences", *Standard Publisher Distributors, Delhi, 4th Edition* .1920.

[9]. Varghese Biju, Malkin Stephen "Rounding and lobe formation during super finishing" *Journal of Manufacturing processes,* (2001).

[10]. Zhao Bo, Gao guofu, Jiao Feng, "Surface characteristics in the ultra sonic ductile honing of ZrO2 Ceramics using coarse grits", *journal of material processing technology,* 2002, 54-60.

[11]. X.S. Zhu, B. Zhao, D.Z. Ma, "Experimental and theoretical research on local resonance in an ultrasonic honing system", *Journal of material processing technology*, 2003, 207-211

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